Summer 2018

Educational Resources: Magnets

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Magnets

These are 4 very different activities. Iron in Cereal is more about nutrition and just uses a magnet to get iron filings. Visualizing Magnetic Fields in 3D gives an idea of the shape of the fields around magnets using iron filings, Dropping Magnets and Making Fields uses the knowledge of magnetic fields to connect electron motion, electricity, and magnets, and Kitchen Magnet Detection goes back to magnetic fields by feeling the "bumps" of a magnet.

Relevant Indiana state standards

There aren't any specific standards as of 2018 for grades 5-8 addressing magnetism/electromagnetic waves/electricity, but it is still an important subject.

6.PS.4 Investigate the properties of light, sound, and other energy waves and how they are reflected, absorbed, and transmitted through materials and space.
- Magnetic fields are a type of electromagnetic radiation. Not related to Iron in Cereal, but it does bring up how magnets work.

7.PS.4 Investigate Newton's first law of motion (Law of Inertia) and how different forces (gravity, friction, push and pull) affect the velocity of an object.
- Related to Dropping Magnets and Making Fields, as the mild current slows a magnet, adding another force

Iron in Cereal

Iron is one of the many minerals required for your body to function. As a result, a lot of breakfast cereals have been fortified with extra iron. To let students visualize exactly how much iron there is, this activity smashes up the cereal and attaches all the iron to a magnet.

Warning: This lab uses cereal, which may contain allergens. Also, the wet cereal goop is pretty messy, so if you plan to physically remove the iron filings from the bags, a sink and plastic tablecloths are probably a good idea.

Supplies

- Iron fortified cereal
  - Normally, flake-based cereals break up pretty well
  - Raisin bran gets a small visible quantity of iron
    - Remember to remove the raisins
  - Grape Nuts do not work very well, as they need soaked in water for 5-10 minutes before breaking up, and all iron is more of iron dust, creating dark spots around the magnet.
- Resealable plastic bags (1 per group)
- Warm water
- Strong magnets (1 per group)
- Optional: small bags/plastic wrap to cover the magnet
  - Definitely recommended, as it helps more easily remove the magnet from the cereal and remove any iron from the magnet.
- Optional: measuring cups to get exact servings of cereal
  - You can also generally guess or pre-measure

Pre-activity questions

- What are some vitamins and minerals that our bodies need?
  - Vitamins A, B, C, D, K, Calcium, Iron, etc.
- How much iron do you think is in 1 serving of cereal?

- Check your box of cereal for the answer to that. It will probably be in mg.

Discussion topics/topics to know

- Nutrition
  - The average adult male has 4 grams of iron. Adult females have around 3.5 grams.
    - This means that it takes around 400 people to have the same amount of iron as the average longsword
      - https://www.tor.com/2017/07/20/sword-forged-from-the-blood-of-your-enemies/
  - Our bodies need iron for our blood
  - Other iron-containing foods include fortified breads, meat, eggs, raisins and dairy.
    - Fortified foods don't get your body as much iron as foods like red meat. That's because "fortifying" food is just trying to add normal iron, like a nail, which our bodies don't process very well. Meat has heme iron, or the form of iron that already exists in your blood.
    - You can still be healthy without eating meat, but that means you do need to make sure you eat plenty of iron-containing foods.
  - Low iron levels can also cause a condition called anemia, where your body doesn't have enough red blood cells.
- Magnets
  - Iron is magnetic

Instructions

1. Give each student/group a bag with 1 serving of cereal in it
   a. The goal is around half full for the bag. You don't want much more or else it gets hard to squish it around later.
2. Start crushing the cereal a little in the sealed bag while dry
   a. Be careful for any developed small holes/leaks during this stage. If a bag becomes too beat up, replace it.
3. Fill the bags around 1/3 full of water and seal them, trying to get most of the air out
4. Let them sit for around 30 seconds
5. Start smashing the cereal in the bag. The goal is to make the cereal fully into almost a paste. The best method I've found is setting the bag on a table, then poking at the top and almost kneading it?
   a. The cereal's pretty soft at this point, so this isn't really a challenge
6. Use the magnet to collect the iron filings.
   a. You can try to leave the magnet outside the bag and shake the cereal around, which keeps the magnet clean and the bag sealed. This method works the best for very strong magnets.
   b. Another method that's messier, but does still keep the magnet clean is covering the magnet in some sort of plastic wrap/bag, then dropping it into the open bag of cereal mess and mixing that around.
   c. If neither of the above methods work, a final option is dropping the bare magnet into the bag, resealing the bag, then squishing it around some more. You will need to fish the magnet out in the end, which can be messy.

Post-activity questions

- Was that more or less iron than you were expecting? Why?

Visualizing Magnet Fields in 3D

This is a relatively short activity. By suspending iron filings in a very viscous liquid, students can observe how the filings follow a magnetic field when going to the magnet.

Supplies

- 1 small bottle per group with a lid or stopper
    - Our bottle was rectangular and around 1 by 1 by 2 inches
- Enough light corn syrup to fill the bottle 1/2 - 2/3 full
    - For worries about corn, a clear glue/water mixture can also work. The glue mix does cause iron filings to rust rather quickly.
    - It does need that viscosity.
- Approx. half a teaspoon of iron filings
    - There just needs to be enough that when the corn syrup is mixed it's evenly distributed at around snow globe-levels of concentration
- Something to mix the corn syrup/iron filings with
    - Depending on the size of the neck of the bottle, a skewer or stirring rod would work nicely
    - Corn syrup is very thick, so the stirring piece can't be flimsy
    - We used a metal spatula
- A semi-powerful horseshoe magnet and/or 2 rare earth magnets
    - For the rare earth ones, check and see if they can hold each other up on opposite sides of the bottle

Pre-activity questions

- Have you ever played with magnets? What happened?
- What happens if two magnets get close to each other?
    - They either attract or repel each other

Discussion topics/topics to know

- Magnetic fields – shape, how they work
- Magnetic poles
    - Can connect with the Earth's poles/compasses and how they work
        - Fun fact: the North Pole is a magnetic south pole! That's why the north side of magnets is attracted to the geographic North Pole!
    - Fun fact – Magnetoreception: Some animals can detect the Earth's magnetic field and use it to orient themselves. This is very common in birds that migrate, but may also be used by bats to navigate longer distances!

Instructions

1. Fill the bottle around 1/3 full with corn syrup.
2. Add the iron fillings
3. Finish filling to around 1/2 – 2/3 full
4. Mix well so the iron fillings are evenly distributed
5. Turn the bottle sideways and place a horseshoe magnet on the side
6. Observe.
    a. The iron fillings will be moving slowly for around 5-10 minutes, so there's plenty of time
    b. Because of the viscosity of the corn syrup, students can also remove the magnet and slowly look underneath and around the bottle to see all angles
7. Once you're done observing there, remix the bottle and set it upright

8. Place one rare earth magnet on either side
9. Observe
    a. There should be long “strings” of filings flowing between the magnets
10. Let it sit for a while then observe the end result

Post-activity questions

- What does a magnet field look like for a horseshoe magnet? Draw it!
- What does the field look like between 2 magnets? Draw it!
- How does this explain what magnets can do?

Extension

- A simple way to show a magnetic field on a flat surface is to place a piece of paper over a magnet, then sprinkle iron filings over it.

Dropping Magnets and Making Fields

You have probably seen this demonstration before. When you drop a magnet down a copper and a plastic tube at the same time, the magnet falls down the copper tube more slowly. This is because, as the magnet falls, it creates a small current in the copper tube, which then opposed the magnetic field of the magnet.

Supplies

- 1 copper tube and 1 plastic tube that are around the same size
- 2 equal-sized magnets that can fit down the tubes
- 2 non-magnetic objects (marbles, pushpins, etc.) that can fit down the tubes
- 2 folded towels (or some other pad)
    - These are to put on the floor to protect the magnets from shattering when falling

Pre-activity questions

- What happens if you drop a pencil and a marble? Why?
    - They’d both fall at the same rate because of gravity.
- What do you predict will happen if you drop 2 magnets?
    - They will also fall at the same rate.
- What if we dropped one magnet down a copper tube, and the other one down a plastic tube? Why?
    - That’s what we’re about to find out.

Discussion Topics/topics to know

- Gravity
    - Why everything falls at the same rate without outside forces
- Magnetic fields
    - Essentially just that they exist and can interact. It’s easy to show with 2 magnets. They repel each other one way and attract another, so you can “push” a magnet around.
- Why some metals aren’t magnetic
    - It depends on how the electrons are arranged in the metal. Individual atoms can have magnetic moments, but only some substances can line up all their atoms to get a full magnetic field.
    - Some non-magnetic metals can be affected with an electronic current.

        - Conducting electricity creates a small magnetic field and magnetic fields can create small electric currents, but metals like copper aren't magnetic if the magnet and metal are both sitting still.
- Electric current and electromagnetism
    - Moving magnets can create an electric current because it moves electrons
    - Electrical current also produces a small magnetic field because electrons are moving
    - Application: Fire doors work with electromagnets. The piece that holds fire doors open is an electromagnet, so that when the power goes out/the fire alarm goes off, the doors automatically shut.
- Most generators work by quickly spinning magnets to create an electrical current. This is also know crank or shake flashlights work. You are using kinetic energy to move a magnet, therefore inducing a current and changing it to electrical energy.

Instructions

1. Set the folded towels on the ground. This part is important simply because magnets, especially rare earth magnets, have a tendency to chip or shatter with heavy impact.
2. Hold both non-magnetic objects at the same height and drop them
    a. It shows that they fall at the same rate
3. Hold both magnets at the same height and drop them.
    a. Make sure you either have an assistant or hold the magnets pretty far apart, as the goal is not to have them attach at the end.
4. Get out both tubes and ask the class what they know about copper and plastic
    a. Copper is a metal, it's in electrical wires, plastic is not a metal
5. Drop both non-magnetic objects down the tubes at the same time
    a. This is just an initial demonstration that it's not the tubes themselves that are physically blocking anything.
6. Drop the magnets down both tubes at the same time
    a. The magnet dropped down the copper tube falls more slowly

Post-activity questions

- Why did the magnet fall down the copper tube more slowly?
    - The magnet created an electrical field and eddy magnetic fields, essentially cushioning itself and slowing down.
- How can we use magnets and electricity to help improve the world?
    - Generators, hydroelectric power, anything the students can come up with.

Optional Extension

- It's possible to build a miniature "flashlight" based on these principles.
    - Using copper wire, a couple LEDs, a tube, and some magnets you can create a shake-powered flashlight
    - This can be used for a demonstration, or students can build them their selves.
    - http://www2.ece.ohio-state.edu/~anderson/Outreachfiles/Making_a_Faraday_Flashlight.pdf

Kitchen Magnet Detection

The everyday flat kitchen magnet has interesting magnetic properties that aren't hard to observe. This is also a great recycling project for all of those flat advertisement magnets that slowly cover fridges everywhere. Have you ever wondered why only one side is magnetic? Why

kitchen magnets don't seem to have defined poles? Essentially, kitchen magnets are made with alternating poles. So, it's a thin strip of magnet aligned one way, then one aligned the other. This can be observed pretty easily.

This activity also fits well with nanotechnology and atomic force microscopes (AFM). AFM sense atoms by running a very tiny tip over a surface and detecting the bumps. This activity is similar, as students feel tiny "bumps" they can't see by running a probe over a surface.

Supplies

- Flat kitchen magnets
    - Each person needs 1 strip and 1 larger piece. The strip can come from the same full magnet.
    - Test your magnets first. The strip piece needs cut perpendicular to the field shifts on the magnet.
        - It sounds a lot more complicated than it is. Essentially, cut a strip off of the short or long side. Run the short side of that strip gently down the back of the magnet. If you feel small "bumps", then congratulations! You cut a strip in the correct direction. If not, then cup a strip from the side you didn't try before and repeat.

Pre-Activity Questions

- What do you know about magnets?

Discussion topics/topics to know

- Magnetic fields
- The basics of magnet poles and why magnets are attracted to each other
- (If this is being connected to nanotechnology/atoms) Atomic Force Microscopes
    - An AFM works by having the tiniest tip and feeling the bumps of larger atoms on a surface.

Instructions

1. Give each person a magnet strip and a larger magnet piece.
2. Have them run the strip gently over the magnet the long way.
3. Then, have them run it the short way.
4. Talk about how it's repelling/attracting in "bumps"

Post-activity questions

- Why would the manufacturers of these magnets only want one side to stick to a fridge?
    - That way, the advertisement will always face out
- How easy was it to feel the "bumps"?
    - You have to be gentle.